R/V New Horizon Cruise NH1111
September 7-16, 2011

ALBACORE OBS Recovery Cruise Report

(Version: September 5, 2012)

Science Party

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Mark Gibaud	OBS Technician	UCSD
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Dave Anderson	Student Technician	UCSD
Meghan Donohue	Resident Technician	UCSD

R/V New Horizon's Ship's Crew

Deck Department

Richard Vullo	Captain
Rene Buck	Chief Mate
Kirstin Capaccioli	Third Mate
Dave Weaver	Bosun
Richard Posthuma	AB
Tony Chi	AB

Engine Department

Mike Breen	Chief Engineer
Willie Brown	Assistant Engineer
William Bouvier	Oiler
Tony Porcioncula	Wiper

Galley

Mark Smith	Senior Cook
Oscar Buan	Second Cook

Introduction

The primary goal of the 2011 ALBACORE (Asthenosphere and Lithosphere Broadband Architecture from the California Offshore Region Experiment) cruise was to recover 34 ocean bottom seismometers (OBSs) in a 150 km (north-south) by 400 km (east-west) region off the coast of Southern California (Fig. 1). The cruise took place on R/V New Horizon, departing out of San Diego on Sept 7, 2011 and arriving back in San Diego on Sept 16, 2011 with no port stops in between.

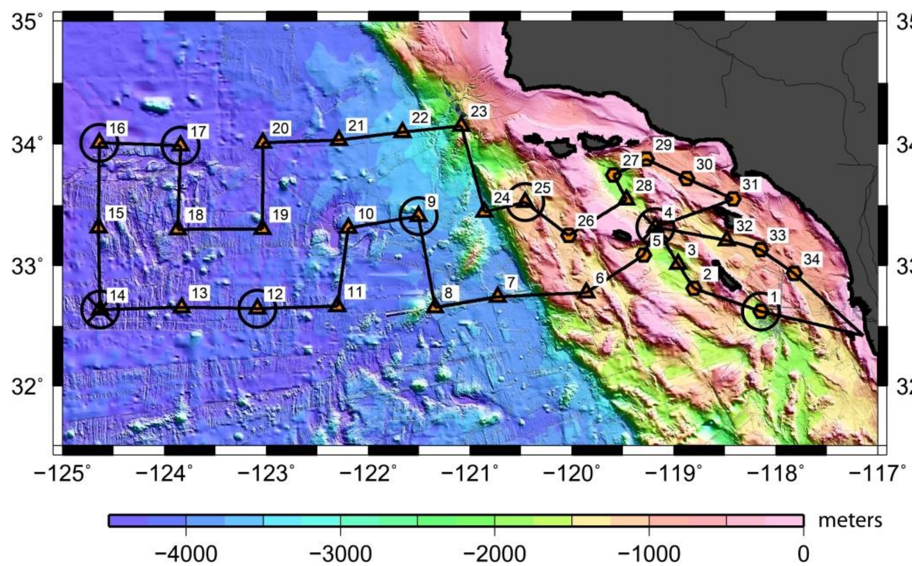

Figure 1. ALBACORE OBS deployment region. Ship track is shown for the Sept. 7-16, 2011 recovery cruise on R/V New Horizon. Bathymetry is a compilation of ship track data sets from the National Geophysical Data Center, U.S. Geological Survey, 2010 ALBACORE deployment cruise, and Smith and Sandwell 1997 global data (Shintaku et al., 2010). Triangles indicate ALBACORE OBS stations. Circles indicate OBS stations with limited or no seismometer data.

The Science Party arrived at the UCSD Scripps Institution of Oceanography (SIO) Nimitz Marine Facility (MarFac) on September 6, 2011. We departed onboard from MarFac on September 7 at 08:00 and arrived back at MarFac on September 16 at noon. Weather during the cruise was mostly cloudy, windy, and cold, resulting in mild to choppy seas with nearly continuously swells during transit and deployment. We did not encounter any serious storm or sea state conditions that hampered the OBS recoveries.

Members of the science party, including senior scientists, acted as observers or loggers ("watchstanders") during predetermined shift hours. Three student volunteers were assigned to shifts that mirrored the bridge officer shifts: i) 12 a.m. - 4 a.m. and 12 p.m. - 4 p.m. (Curie and Teodor), ii) 4 a.m. - 8 a.m. and 4 p.m. - 8 p.m. (Brian and Kelsey), and iii) 8 a.m. - 12 p.m. and 8 p.m. – 12 a.m. (Jennifer, Paige, and Lennin). Monica and Dayanthie rotated as necessary so that at least one was on call during the OBS recoveries.

Two Navy-contracted engineers from Science Applications International Corporation (SAIC) and Johns Hopkins University Applied Physics Lab (JHAPL) accompanied us on the cruise as part of the science party. The purpose of their involvement was to archive the entire raw dataset for 16 out of the 34 stations for subsequent screening, and to low-pass filter (4 Hz) those data for immediate use by the Science Party. These 16 stations included every station in the Inner and Outer Borderland: stations #1-6, and #25-34. The data were screened for signals of national security interest at SAIC and JHAPL during the subsequent four months (September-December, 2011). Onboard data processing operations involving the SAIC and JHAPL engineers were smooth and efficient. The engineers were helpful during the data copy and raw-data-to-miniseed format conversion process because they had brought additional 64-bit computers on board with them which dramatically sped up the process. They met with OBSIP staff about a week before the cruise to prepare for handling the data during the cruise. Before the cruise, Phil Thai spent time modifying SIO OBSIP data conversion code, originally designed for 32-bit systems, to run on the Navy-contracted engineers' 64-bit computers.

Scientific Motivation

The overall objective of the ALBACORE project is to understand the tectonic interaction at the Pacific-North America plate boundary by identifying the physical properties and deformation styles of the Pacific plate and tectonic transition to continental lithosphere. The results will be used to distinguish among contrasting upper mantle geodynamic scenarios that predict large-scale mantle flow patterns beneath western North America. Seismic studies using broadband ocean bottom seismometer (OBS) data will characterize the driving plate motion consequences of collision between the rift system, a fragmented subducted plate, the geometry of the San Andreas transform fault system, and crustal block rotations. The boundaries for the OBS array overlapped the region of complex breakup and fracture of the Pacific plate nearshore where several microplates are observed. The array extends far to the west to provide comparison with oceanic lithosphere that is not fractured.

Studies using seismic anisotropy and plate motion GPS data in western North America infer SW-NE plate motion over uniformly EW mantle flow. Some studies predict eastward passive drag with little or no mechanical coupling between lithosphere and asthenosphere, while others predict westward active drag. In addition, a study based on a compilation of plate velocity and anisotropy results suggests that toroidal flow occurs in the asthenosphere beneath much of the western U.S. to accommodate mantle flow around the subducted Juan de Fuca plate. If this is the case, then toroidal mantle motions also occur below the Pacific-North American plate boundary in southern California. If coupling with the lithosphere is occurring, this could be contributing significant driving forces for plate motions and fault loading. These different scenarios have implications for whether lithospheric deformation occurs passively with little or no mechanical coupling with the deep mantle, or actively with the primary source of plate motion coming from the deep mantle.

A combined study of azimuthal and polarization anisotropy from dispersive Rayleigh wave and SKS splitting studies recorded on the OBSs will distinguish the lithospheric and asthenospheric components of anisotropy from which to infer lithospheric-asthenospheric coupling. If splitting reflects the shear strain field related to deeper mantle flow possibly only weakly coupled to surface plate motions across the plate boundary, no change in fast directions or amplitude would be expected in and west of the southern California Borderland.

The widely observed uppermost mantle high-velocity anomaly beneath the Transverse Ranges exhibits an apparent rotation with decreasing depth in the uppermost mantle. The western boundary of the Transverse Ranges high-velocity anomaly appears to terminate at the coastline, but its western lateral extent is not imaged due to lack of offshore data. The high-velocity seismic anomaly and adjacent low-velocity anomalies may be the result of asthenospheric flow processes such as small-scale upwellings and downwellings. A combined tomographic study using onshore and offshore seismic stations with sufficiently long-period data, will provide estimates of lithospheric thickness across this plate boundary to test these various model predictions.

The recorded local earthquake data will be used to map offshore fault and seismicity features, and to compile phase arrival times for crustal velocity modeling. The local offshore seismicity recorded by the OBS array is expected to produce a more accurate offshore hypocenter catalog which will be examined for seismicity. Unresolved features of offshore earthquakes are that offshore hypocenters do not always closely correlate with mapped fault locations indicating either the existence of unmapped faults or errors that are too large in the hypocenters to associate them with mapped faults, local magnitudes are almost always smaller than moment magnitudes, and aftershock sequences are smaller than those of onshore earthquakes, suggesting differences in strain release styles and geometries between onshore and offshore faults. Wherever possible, focal mechanisms will be computed for the offshore earthquakes. Of additional interest are tsunami implications from reverse/thrust faulting mechanisms. Focal mechanism analysis will help identify the potential for faulting necessary in evaluating the tsunami risk.

During the OBS deployment the devastating M_w=9.0 Tohoku, Japan earthquake and subsequent tsunami occurred and were recorded on our OBS network (Fig. 2). The earthquake occurred on March 11, 2011 (Julian day 70) at 05:46:24 UTC, and the epicentral location was 38.297° N and 142.372° E. The majority of casualties and damage occurred in Iwate, Miyagi and Fukushima from a Pacific-wide tsunami that had a maximum runup height of 38 m. The earthquake, which occurred near the northeast coast of Honshu, was the result of thrust faulting on or near the subduction zone plate boundary between the Pacific and North America plates at the Japan Trench subduction zone. Body waves and surface waves were well-recorded on every functioning OBS in our network, and the tsunami was clearly recorded on the differential pressure gauge (DPG) instruments that accompanied each long-period OBS.

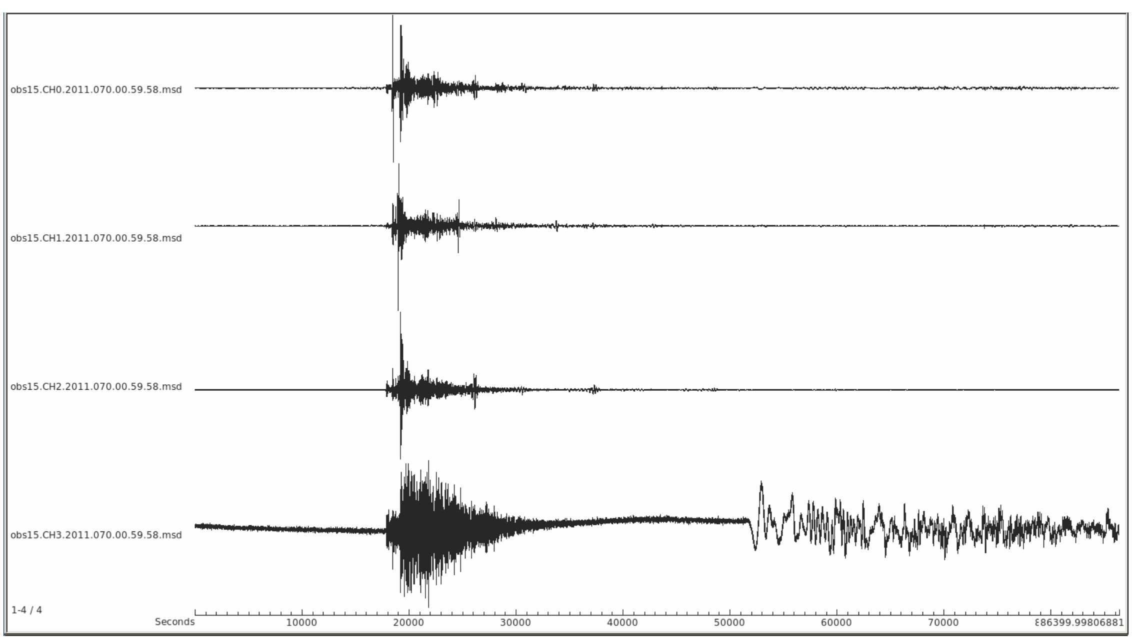

Figure 2. March 11, 2011 M_w=9.0 Tohoku, Japan earthquake recorded on OBS15. Channel channels 0 and 1=horizontals, 2=vertical, and channel 3=DPG.

Recovery and instrumentation logistics

The OBSs sat on the seafloor for 12 months before recovery. The OBSs were set to record earth vibration data as continuous velocity time series at a sample rate of 50 samples per second. The OBS locations were chosen such that approximately uniform station spacing could be achieved, taking advantage of existing California Integrated Seismic Network stations installed on Catalina, San Clemente, San Nicolas, Santa Barbara, Santa Rosa, and San Miguel Islands. In the shallow-water Continental Borderland region, station spacing was approximately 50 km, and in the deep-water oceanic plate region, station spacing was approximately 75 km. The OBSs consist of three types: 21 three-component long-period Nanometrics Trillium 240 sensors with differential pressure gauges (DPGs), 3 three-component long-period Nanometrics Trillium T-40 sensors with DPGs, and 10 three-component short-period Sercel L-28 sensors with hydrophones. Each long-period OBS weighs approximately 1000 lbs (according to Ernie Aaron: 911 lbs) in air with the anchor. Without the anchor, each weighs 850 lbs. Negative buoyancy in water as the OBS is sinking adds 50 lbs, and positive buoyancy as the OBS is rising without anchor subtracts 50 lbs. Each short-period OBS weighs approximately 400 lbs (according to Ernie Aaron: 427 lbs) in air with the anchor. Without the anchor, each weighs 300 lbs. Negative buoyancy in water adds 40 lbs and positive buoyancy subtracts 40 lbs. The loaded short-period rack (with three SP OBSs) is 1018 lbs and the loaded 24-transducer rosette rack is 1091 lbs.

SIO Seismometers

The OBS dataloggers were the same for every station, and were Scripps-developed instruments that consisted of four channels recording waveform data initially at 4000 sps. The datalogger contained solid state memory (CF) cards and a temperature-compensated oscillator. Power consumption was 350 mW and the equipment was rated to 6000 m water depth where pressure is approximately 10,000 psi. Downsampling to the final 50 sps occured in the datalogger in a series of stages involving anti-alias FIR filters.

The long-period (LP) sensors are three-component Nanometrics Trillium 240s (“T-240”) and Trillium 40s (“T-40”). The response of the T-240 is flat in velocity from 240 seconds to 35 Hz. The measured self-noise is below the NLNM (Peterson New Low Noise Model) from 100 seconds to 10 seconds. The clip level is 15 mm/s up to 1.5 Hz. Power consumption is 800 mW nominal and the sensor has 20 g shock resistance. The T-240s have motorized mass centering; no mass lock is required. The short-period (SP) sensors are three-component Sercel L-28 (“L-28”) passive velocity transducers.

Each LP OBS contained a Differential Pressure Gauge (DPG). They each also had a battery bottle to power the Trillium sensor and two mechanical release mechanisms. Each SP contained a high-frequency hydrophone and one mechanical release mechanism. The DPGs measure differential pressure between 100 s and a few Hz, and the hydrophones measure absolute pressure between 1 Hz and several thousand Hz.

The seismometers were able to level themselves up to 120 degrees correction by the LPs and up to 45 degrees by the SPs using a gimbal system. The LP gimbal system contained two-axis active leveling and a three-point coupling lock. The system was low-power, but the more often leveling was required, the more battery power was required. Sensor ball leveling occurred once an hour for the first 24 hours, then once per day for the first seven days, then a level check once per week for the rest of the deployment period.

The acoustic release system has an 18-V release pack for disconnecting the OBS from the metal grate (“anchor”) that keeps it on the seafloor. It operates by frequency shift key operation and there are unique codes for each serial number. It contains two redundant release circuits and is also rated to 6000 m water depth. The flotation system consists of 2 components. Each seismometer has 88 lbs of glass buoyancy and 12 lbs of syntactic foam buoyancy. The net buoyancy of the entire system is 46 lbs.

Acoustic Transponders

Communication with the OBSs was made possible by acoustic pings using acoustic communication boxes (“deck units”) provided by SIO OBSIP. All acoustic signal pings to the OBSs were made in the 9-13 kHz range. More specifically, the acoustic units were interrogated with 11 kHz pings and confirmation pings were received from the OBS at 13 kHz. In order to enable or release one of the OBSs, we interrogated it with a specific code which was unique for every command type and for each individual acoustic unit. These codes were preset (hardcoded) and the OBS acoustic code depended on the specific acoustic unit selected for the site. All communication with the OBSs used an OBS station-specific identifier code as well as additional codes to identify the OBS’s operational status (e.g., “enable” to wake the station up and “disable” to put the station to sleep). The acoustic codes are transmitted on a frequency shift key principle. When we left each site, the units were disabled. It would be nearly impossible for someone to intentionally or accidentally trigger a release (i.e., the Navy during an exercise) without knowledge of our specific codes.

Both OBSIP acoustic communication boxes developed problems during the cruise. The newer primary orange box stopped communicating via the hull transducer. Either there was a bad transducer connector or the electronics inside the deck box went bad. The OBS techs were unable to repair this box during the cruise. The older back-up yellow box developed a power-related problem below the main panel. It was fixed the same day by removing the battery and running it solely on A/C power.

Also as part of the communication system, each OBS was equipped with a radio beacon (an Edgetech acoustic transponder system). The Edgetech transponder hardware consists of off-the-shelf equipment commonly used by fishermen and for Acoustic Doppler Current Profiling and moorings measurements. The radio beacons emit acoustic signals and were tested individually before each OBS drop using a Radio Direction Finder (RDF) receiver in New Horizon’s bridge as well as a portable RDF receiver carried by OBS techs. The RDF receiver uses a directional antenna arrangement to determine the direction of arrival of the OBS’s radio signal. The RDF was used to identify when the OBS was on the surface of the water, and which direction relative to the ship it was in while floating.

In addition, each OBS was equipped with a strobe light to aid in recovery at night. The strobe light has a photo cell (light-sensitive switch) so that it will only go off between dusk and dawn during the recovery process.

OBS Recovery Details

OBS Station 1

OBS station 1 was an SP L-28. Curie Ahn was the watchstander for OBS01 with a local date and time of 09/07/11, 13:23 and Beaufort Sea State number 3. On Julian Day (JD) 250 at 20:23 UTC, New Horizon was approximately 1000 m from the OBS location. Both the 3.5 kHz and the 12 kHz Knudsen Echosounder channels were kept on since they did not conflict with the signals sent from the acoustic box. The first enable code was sent at 20:23 UTC via seven pings, and OBS01 was enabled right away at 20:23 UTC. A burn code was sent at 20:26 UTC and the OBS responded right away at 20:27 UTC that the burn code was successful. At 20:41 UTC, OBS01 was confirmed to be off the seafloor with an estimated UTC arrival time on the surface of 21:20. This rise time was calculated based on the depth at the recovery site of approximately 2062.4 m. At 21:18 UTC OBS01 was sighted from the ship; the radio was supposedly heard on the bridge prior to this time. At 21:48 UTC, OBS01 was safely recovered on deck at a surface location of 32° 37.31' N and 118° 08.59' W. The OBS time tag displayed 21:58:005020528. The true wind speed was 8.6 m/s with a true wind direction of 291.1°. Calculated rise speed: 53 m/min.

OBS Station 2

OBS station 2 was an SP L-28. Kelsey Brunner was the watchstander for the recovery of OBS02 with a local date and time of 09/07/11, 08:32. On JD 251 at 01:33 UTC, New Horizon was approximately 2000 m from the OBS drop site. This time, the 12 kHz Knudsen Echosounder channel was turned off at 01:32 UTC while the 3.5 kHz channel was kept on. A series of enable codes were sent at the following times: 01:33 UTC, 01:34 UTC, 01:35 UTC, 01:36 UTC, 01:37 UTC, 01:38 UTC, 01:39 UTC, 01:40 UTC and OBS02 was finally enabled at 01:40 UTC. It appears that many dolphins in the area were attracted by the enable code and may have sent false signals to the acoustic box; this could explain why multiple enable codes had to be sent. At 01:42 UTC the burn code was sent and was successful right away. By 02:00 UTC the crew was confident that the OBS was off the seafloor with an estimated UTC arrival time on the surface of 02:25 UTC. This rise time was calculated based on the depth at the recovery site of approximately 1450 m. At 02:25 UTC, the bridge confirmed visual and radio at surface location 32° 48.794' N and 118° 48.368' W. When OBS02 was on deck at 02:36 UTC, one of the technicians noted that the strobe light on the OBS was malfunctioning. The OBS time tag displayed 02:46:005390425. The true wind speed was 6.0 m/s and true wind direction was 269.1°. Calculated rise speed: 58 m/min.

OBS Station 3

OBS station 3 was an LP T-240. The watchstander for the recovery of OBS03 was Paige Logan. The local date and time was 09/07/11, 22:30. At 04:05 on JD 251 UTC, the vessel was 2000 m from the site. The OBS crew sent the enable code at 04:05 UTC. Several pings were sent between distances of 1000 m and 2000 m from the site. OBS03 was finally enabled at approximately 1200 m away at 04:13 UTC. The estimated surface arrival time was not recorded. Burn code #2 was sent at 04:15 UTC and was confirmed unsuccessful at 04:30 UTC. Burn code #2 was sent again at 04:32 UTC and was confirmed as unsuccessful at 04:52 UTC. After recovery, Burn code #2 was found to have been successful by back-calculating from the surface time and depth. At 04:52 UTC, burn code #1 was sent and confirmed unsuccessful at 05:08 UTC. Burn code #1 was sent again at 05:09 UTC with OBS03 reaching the surface before success had been confirmed. OBS03 was sighted by the bridge and the RDF was heard at 05:20 UTC. Back-calculation later revealed that OBS03 released from the bottom at approximately 04:40 UTC. OBS03 was recovered safely on deck at 05:42 UTC. The surface latitude and longitude of recovery was 33° 00.636' N and 118° 57.291' W, respectively. GPS “time tag” time synchronization was carried out at 05:49:57.9972527 on JD 251. The recovery depth was 1746.5 m with a wind speed and direction of 5.4 m/s and 269.2° respectively. The Beaufort Sea State was a 3 at the time of recovery. Calculated rise speed: 44 m/min.

OBS Station 4

OBS station 4 was an LP T-240 and was never recovered. The first attempt to pick up OBS04 occurred on JD 251 at 08:20 UTC. The hull transducer was turned on at 08:20 when the ship was approx. 2000 m from the OBS seafloor site. On day 251 at 08:20 UTC, the first of several enable codes was sent. At 08:26, the OBS was enabled successfully. At 08:27, the first of several burn codes was sent, which was not deemed successful. Seven more burn codes were sent between 08:27 and 10:58. The Echosounder was turned off at 10:26.   Between the 5th and 6th burn code, the OBS techs swapped acoustic communication boxes. Although the second older box worked well, the 8th burn code was still not successful. We couldn’t hear clear double pings even after the 3rd burn, so at 09:04, the ship was moved right over the seafloor site, without success. At 11:14, after the 8th burn code was sent, the OBS tech confirmed that the OBS was still on the bottom; this was determined while the ship hovered directly over its seafloor location. OBS04 was disabled and the Echosounder was turned back on. At 11:24, a possible strobe was sighted off the aft, bearing 135° relative to the vessel. The lab asked the bridge to slow down to determine if the OBS had surfaced after all. Nothing was found and the bridge reported that only aircraft were in the vicinity. At 500 m from the site, a slant range of 1159 m confirmed that OBS04 is still on the bottom. The captain confirmed the slant range hypothesis. The vessel was turned into the direction of the next OBS.

OBS Station 5

OBS station 5 was an SP L-28. Kelsey Brunner was the watchstander for the recovery of OBS05. The local date and time for the recovery was 09/08/11 and 05:04, respectively. The hull transducer was turned on at 13:04 UTC on JD 251. The 12 kHz channel of the Knudsen Echosounder was off prior to reaching the recovery site. The enable code was sent at 13:04 UTC and enabled at 13:05 UTC. The burn code was sent at 13:07 UTC and was considered successful at 13:08 UTC. OBS05 was confirmed to be off the seafloor at 13:22 UTC with the ETA to the surface of 13:46 UTC. At 13:52 UTC, OBS05 was sighted from the ship with the RDF heard ‘loud and clear.’ OBS05 was successfully recovered and on deck at 14:06 UTC with a surface latitude and longitude of 33° 05.180' N and 119° 17.859' W, respectively. The depth of the recovery site was 1630 m with a wind speed and direction of 4.0 m/s and 301.4°, respectively. The Beaufort Sea State was a 2 during the recovery. The GPS time tag was 2011:251:14:27:00.7627667. Calculated rise rate: 37 m/min.

OBS Station 6

OBS station 6 was an LP T-240. Paige Logan was the watchstander for the recovery of OBS06 at 10:24 local time on 9/8/11 (JD 251). An enable code was sent at 17:25 UTC. The instrument was enabled at 17:29 UTC at a distance of ~1000 m from the OBS location. The first burn code was sent at 17:33. This burn was checked at 17:48 and we were not able to get a good enough signal from the OBS to determine if it was off the seafloor. The bridge was then asked to move in closer. A second burn code was sent at 17:57 from closer range, but we were still unable to communicate with the OBS. Passing directly over the instrument at 17:59 and sending another burn code was successful and it was positively determined to be off the bottom. Based on a depth of 1180 m, the estimated time of arrival was 26 min after the last burn command was sent. Its radio signal was heard by the bridge at 18:17 UTC, and was spotted shortly thereafter at 18:18. OBS06 was safely placed on the deck at 18:35 UTC at surface location 32° 46.669' N, 119° 51.238' W, and a depth of 1180.8 m. Calculated rise rate: 54 m/min.

OBS Station 7

OBS station7 was an LP T-240. Kelsey Brunner was the watchstander for the recovery of OBS07. The local date was 09/08/11 and the local time was 16:13 at the time of initializing communication with the instrument. The 12 kHz channel of the Echosounder was off during this recovery and remained off for the remainder of the cruise unless noted otherwise. The enable code was sent to OBS07 at 23:13, 23:15 and 23:17 UTC. The enable code sent at 23:17 was successful. This allowed Ernie Aaron to send burn codes to the OBS at 23:19 at a distance of 3.7 km, at 23:27 at a distance of 2 km, at 23:29 at a distance of 1.35 km, and at 23:30 at the same distance. This last Burn code was successful and we were able to verify that OBS07 was off the seafloor at 23:49. The ship had to be repositioned directly over the site due to poor communication with the instrument, but repositioning the ship fixed the communication issues. A survey from last year's deployment indicates that the southwest quadrant of this particular site has known communication "blind spots." Based on the depth of about 3800 m at the recovery site, we estimated that the OBS would take approximately 85 min to reach the surface. This gave an estimated arrival time of 01:15 UTC on JD 252 (or 18:15 local time). The OBS was sighted from the ship off the starboard side at 2:01 UTC, well after the estimated arrival time. This may have happened because range signals were not conclusive as to whether the instrument was still rising or if we were moving away from it. The bridge also did not hear the radio at first to give an indication of where to look for it. However, once the OBS was spotted, the rest of the procedure went smoothly and quickly. The OBS was recovered at surface location 32° 44.521' N and 120° 43.316' W, and safely placed on deck at 2:15 UTC. The OBS appeared to be sitting low in the water, but there was no apparent damage to the instrument. There was green mud caked on the bottom which may have caused it to rise more slowly than anticipated. Calculated rise rate: 29 m/min.

OBS Station 8

OBS station 8 was an LP T-240. Paige Logan was the watchstander for the recovery of OBS08 with a local time and date of 23:07, 09/08/11. The vessel was approximately 2000 m from the site at 06:07 UTC on JD 252. The enable code was sent at 06:12 UTC on JD 252. There were reply pings, but it was uncertain if the instrument was enabled. The bridge was instructed to move west to attempt to get better communication. The first burn code was unsuccessful. The second burn code was sent at 06:20 UTC. An OBS crew member was unable to verify success. He informed the bridge to move closer to the site at 06:25 where success was finally verified. OBS08 was confirmed off the seafloor at 06:38 UTC with an 87 minute rise time, making the ETA 08:00 UTC (01:00 local time). At 08:17 UTC, OBS08 was sighted from the ship. OBS08 was recovered safely on deck at 08:44 UTC at surface latitude and longitude of 32° 39.07' N and

121° 20.34' W, respectively. The GPS time was synchronized and carried out at 2011:252:08:57:53585463084 UTC. The recovery depth was 3900 m, with a wind speed of 8.1 m/s, wind direction of 312.8°, and a Beaufort Sea State of 5. Calculated rise rate: 39 m/min.

OBS Station 9

OBS station 9 was an LP T-240. Kelsey Brunner was originally the watchstander for the OBS09 recovery but then Paige Logan took over at the shift change. OBS09 recovery began at the local time and date of 07:45, 09/09/11. The vessel was approximately 2000 m from the site at 14:45 UTC on JD 252. The vessel was approximately 1000 m from the site at 14:50 UTC. The enable code was sent at 14:46 UTC and the OBS was enabled on the first attempt. The first burn code was sent at 14:51 UTC. Mark Gibaud was unsure if the first burn command worked, so he sent a second burn code at 14:53 UTC. The OBS didn't catch the second burn command because it was in fact already in the burn sequence from the first burn command. At 15:08 UTC, Mark called the bridge and asked them to steer over the drop site in order to get a better signal to see if the burn code was successful. At 15:14 UTC, good responses were received from the OBS that indicated motion, but Mark wanted to wait to get several consistent responses before declaring that it had released from the seafloor. At 15:20, Mark was relatively sure the OBS was off the bottom but asked the bridge to maneuver the ship directly over the OBS location. He sent out a third burn command at 15:23 UTC just in case the pings he was getting were false. At 15:48 UTC, we started getting better pings and the OBS appeared to be at a depth of approximately 2000 m. Note that all three burn commands were sent to wire 2. We later back-calculated to estimate that OBS09 came off the seafloor at approximately 15:06 UTC with an 85 minute rise time, making the ETA 16:40 UTC (09:40 local time). At 16:48 UTC, OBS09 was sighted from the ship but the bridge never said anything about hearing the radio so we're unsure if they heard it. OBS09 was recovered safely on deck at approximately 16:57 UTC with a surface latitude and longitude of 33° 24.147' N and 121° 30.364' W, respectively. The GPS time was synchronized and carried out at 2011:252:17:02:59.8691500 UTC. The recovery depth was approximately 3810 m, with a wind speed of 12.4 m/s, wind direction of 330.1°, and a Beaufort Sea State of a high 4. Calculated rise rate: 37 m/min.

OBS Station 10

OBS station 10 was an LP T-240. Teodor Sotirov was the watchstander during recovery of OBS10 on September 9, 2011. Once the ship was approximately 2000 m from the instrument at 20:38 UTC, the first enable code was sent and was deemed successful. A burn code was then sent at 20:39, 20:46, 20:52, and 21:01 UTC, none of which were successful. The SIO OBSIP acoustic communication box was then switched to the older yellow one at 21:08 and another burn code was sent at 21:10 and 21:20. Communication with the OBS indicated that it was still on the seafloor and none of the previous burn codes had been successful. More burn codes were sent at 21:28, 21:35, and 21:43. At 21:53, we could tell that the instrument was off the bottom, so one of the last burns must have been successful. Based on a water depth of approximately 3700 m, we estimated that it would take about 85 min. to surface. Measured ranges indicated that the OBS reached the surface at 23:38 and it was spotted from the bridge 20 min. later at 23:58. It was recovered from surface location 33° 18.763' N, 122° 11.708' W, and a depth of 3708 m. It was placed on the deck at 00:16 UTC on JD 253, and GPS synchronization occurred at 00:20 UTC. This OBS took much longer to reach the surface than anticipated. Calculated rise rate: 29 m/min.

OBS Station 11

OBS station 11 was an LP T-240. Paige Logan was the watchstander for OBS11. The local date and time was 09/09/11 and 21:16, respectively. The vessel was 2000 m from the OBS station at 04:16 UTC on JD 253. The 12 kHz channel of the Knudsen Echosounder was off prior to the pickup. The first ping was sent unsuccessfully at 04:00 UTC, prior to reaching 2000 m distance. At 04:02, 04:08, 04:11, and 04:13 UTC, pings were sent. The OBS crew later believed that the 5th ping was successful, but requested that the bridge hover the vessel over the site to confirm. At 04:27, the vessel was hovering approximately 40 m east of the OBS location. At 04:29 UTC, the burn code was sent successfully with a confirmation that the instrument was off the seafloor and rising. The estimated time to surface was 06:16 UTC, 23:16 local time the day before. The instrument was sighted and the RDF heard from the ship at 06:36 UTC. OBS11 was recovered safely on deck at 06:50 with a surface latitude and longitude of 32° 39.619' N and 122° 18.372' W, respectively. GPS time tag synchronization was carried out at UTC 253:06:58:00.8943059. The depth of the recovered OBS was approximately 4196.2 m, with a wind speed and direction of 8.4 m/s and 301.6°, respectively. The Beaufort Sea State was recorded as a 4, but the wind speed places it closer to 3. Calculated rise rate: 33 m/min.

OBS Station 12

OBS station 12 was an LP T-40. Kelsey Brunner was the watchstander for the recovery of OBS12, on September 10, 2011. At 11:06 UTC on JD 253, the ship was 2000 m from the OBS location. An enable code was sent at 11:06, 11:07, 11:08, and 11:09 UTC. This last enable code was successful so the OBS was enabled at 11:09. A burn code was sent shortly thereafter at 11:10 and was deemed successful on the first try. At 11:28, it was determined that the OBS was off the seafloor but rising slowly. We used the average of 45 m/min to estimate that it would arrive on the surface at 13:30 UTC, or 6:30 local time, but guessed that it would likely appear sometime later because it was rising so slowly. This hypothesis was indeed correct, as it was spotted and heard as soon as it surfaced at 14:03 – a full half hour after the estimated arrival time. It was safely placed on the deck at 14:15 UTC at surface location 32° 38.657' N, 123° 05.127' W, and at a depth of 4124 m. When it was placed on the deck, we observed that there was mud caked on the bottom of the OBS, which probably contributed to its slow rise rate. Calculated rise rate: 27 m/min.

OBS Station 13

OBS station 13 was an LP T-240. Paige Logan and Teodor Sotirov were the watchstanders for the OBS13 recovery with a local date and time of 09/10/11, 11:18 and Beaufort Sea State of 2. On JD 253 at 18:18 UTC, the vessel was approximately 2000 m from the OBS13 location. An enable code was sent at 18:18 UTC and was confirmed successful at 18:21 UTC. A burn code was sent at 18:21 UTC to release OBS13 and 15 minutes later at 18:36 UTC, the first burn was confirmed to be successful. By 18:28 UTC, the crew noted that the OBS was already off the seafloor and its expected UTC arrival time on the surface was 21:15 UTC. This rise time was calculated based on a water depth of 4281 m and taking into consideration previously observed fine mud on the bottom of the OBS. At 21:11 UTC both visual and radio of OBS13 was confirmed at a surface location of 32° 39.36' N and 123° 49.427' W. The OBS time tag indicated 21:28:595998144. The true wind speed was 1.6 m/s and true wind direction was 305°. Calculated rise rate: 26 m/min.

OBS Station 14

OBS station 14 consisted of an LP T-240 and was never recovered. Below is a summary of the attempt to recover it. Kelsey Brunner was the watchstander for the recovery of OBS14 up to 20:00 local time and then replaced by Paige. At the beginning of the recovery of OBS14, the local date and time were 09/10/11 and 18:40. On JD 254 at 01:43 UTC, the vessel was 2000 m from OBS14. Ernie Aaron attempted to make contact with OBS14 approximately 3000 m away. At this time, the 12 kHz channel of the Echosounder was off. At 02:12 UTC the 3.5 kHz channel of the Echosounder was turned off. At 02:13 UTC, the ADCP was turned off in an attempt to create complete acoustic frequency silence. Multiple enable and burn codes were sent approximately every 1-2 minutes, beginning at 01:51 UTC. There was no communication with OBS14. At this time, the OBS crew instructed the bridge to circle the site at a distance of 500 m in an attempt to find a location with good communication. The Echosounder had profiled a 50 m high 'hump' or 'dome' almost exactly over the site, and it was hypothesized that this feature may be blocking communication. The 2010 deployment log noted this particular site as being a 'flat plateau' with deep sediments without mention of the 'dome.'

At 02:29 UTC, the OBS crew contacted the bridge and requested that the vessel cut south from the 500 m circle, passing directly over the site, and pick up circling the site again from the south at a distance of 1000 m. At 02:34 UTC, the vessel passed directly over the site and reached the southernmost point and began the 1000 m survey at 02:41 UTC. At 02:50 UTC, a ranging signal was sent to determine if the OBS was receiving signals but it did not respond. At 02:55 UTC, it was determined that no response was being received. The bridge was informed to continue heading south and begin the 1000 m clockwise survey.

At 03:37, a second SIO OBSIP acoustic communication box was set up. The OBS crew called the bridge at 03:37 and asked for the vessel to be positioned directly over the drop location due to issues with the communication boxes. Also, it was decided to lower a rescue beacon down to the instrument for approximately 20 minutes to try to communicate with the OBS. At 04:25 UTC, the beacon was deployed. A bag full of decorated styrofoam cups was attached to and lowered with the beacon. At 04:30 UTC, a burn2 command was programmed to be sent every two minutes and the depth to which the beacon would be lowered was established to be 4200 m. It became clear that there were issues with the SIO OBSIP acoustic communication box (8011M). Apparently, even though the box's power was being supplied directly through a 110V outlet, the battery was faulty. The OBS crew removed the battery, thus removing the issue.

At 04:42 UTC, while the beacon was being lowered by winch, the winch readout was not working. The bridge crew, as well as Megan Donohue, were troubleshooting the issue. The beacon reached a depth of 1500 m at 04:42 UTC, but the winch's lab screen display was still not working. At 04:58 UTC, the wind shifted direction causing the vessel to roll more than usual. A depth of 2000 m was reached at 05:05 UTC with the speed of the winch payout calculated to be 59 m/min (it was set at 60 m/min). The beacon reached a depth of 2500 m at 05:14 UTC. At 05:16 UTC, the 3.5 kHz channel of the Knudsen Echosounder was turned back on. The beacon reached a depth of 3000 m at 05:23 UTC and 3500 m at 05:33 UTC. The OBS crew went to the bridge to get the settings from the winch display, attempting to troubleshoot the winch readout display in the main lab. The beacon reached a depth of 4000 m at 05:48 UTC. Megan requested the payout to be reduced to 30 m/min until the beacon reached a depth of 4150 m. The plan was to hold the beacon at a depth of 4150 m for approximately 20 minutes as the beacon sends a burn command every 2 minutes.

At 06:16 UTC, Megan asked for the winch to be brought back up to 100 m at a rate of 60 m/min. The plan was to wait for two hours because it would take this long for the instrument to reach the surface if the burn command had been successfully received by the instrument. At 06:57 UTC, the beacon reached 1000 m and was safely placed back on deck at 07:34 UTC. After waiting the appropriate time for the instrument to rise but still seeing no sign of it, it was decided that the instrument had failed to receive the burn command and the bridge was notified to begin traveling to OBS station 15.

OBS Station 15

OBS station 15 consisted of an LP T-240 sensor. Kelsey Brunner was the watchstander for the recovery of OBS15, until 08:00 local time on 9/11/11 at which time Paige Logan took over. The first enable code was sent at 13:32 UTC on JD 254 when the ship was ~2750 m from the OBS location. Another enable code was sent at 13:34 UTC when the ship reached a distance of 2 km. This was determined to be successful at 13:35, so a burn code was sent, also at 13:35. This was successful on its first try. At 13:52, the OBS was off the seafloor. Since several of the previous OBSs rose much more slowly than expected, a rise rate of 30 m/min and depth of ~4200 m was used to calculate the estimated arrival. Based on this calculation, we estimated that the instrument would arrive on the surface at 16:10 (9:10 local time). This was a fairly accurate estimate, as its radio was heard at 16:07 and it was spotted at 16:08. The OBS was safely placed on deck at 16:18 UTC at a surface latitude and longitude of 33° 18.789' N, 124° 34.053' W, and a depth of 4260 m. The GPS was synchronized at 16:23. This was a straightforward recovery with no issues. Calculated rise rate: 32 m/min.

OBS Station 16

OBS station 16 consisted of an LP T-240 sensor. Curie Ahn was the watchstander for the recovery of OBS16 at the local date and time of 09/11/11, 13:48, and Beaufort Sea State of 2. The true wind speed was 2.2 m/s and true wind direction was 154.5°. On JD 254 at 20:47 UTC, the vessel was approximately 2000 m from the OBS location. Prior to this arrival, two enable codes were sent at around 20:35 UTC and 20:36 UTC, and excellent communication with the OBS was established. Since these initial attempts were successful, the technicians attempted two burn codes at 20:37 UTC and 20:39 UTC. Fifteen minutes later, at 20:55 UTC, OBS16 was enabled and the second burn at 20:39 UTC was confirmed successful. By 20:57 UTC, the OBS was off the seafloor and its estimated arrival time on the surface was 22:45 UTC. This rise time was calculated based on the depth at the recovery site of approximately 4565 m. Around 22:42, we lost the ability to range to the instrument. However, we regained this capability and got decreasing ranges starting from 22:54 that indicated that the instrument was still rising. The OBS made it to the surface at 23:30, where it was both seen and heard. It was safely placed on deck approximately ten minutes later around 23:40, at a surface location of 34° 00.982' N, 124° 38.189' W, and a depth of 4565 m. There was some corrosion of small, exterior, metal pieces (such as nuts and bolts) on the OBS. GPS synchronization was carried out another ten minutes later at 23:50; the OBS time tag showed 23:45:56.3124593. Calculated rise rate: 39 m/min.

OBS Station 17

OBS station 17 was an LP T-240. Kelsey Brunner began the recovery watch for OBS17 at 19:55 local time on 9/11/11. Paige Logan then took over at 20:00. Enable codes were sent at 02:55 and 03:01 UTC on JD 255 from a distance of ~2000 m. Enable and burn codes were sent at 03:07, 03:10, 03:12, 03:14, 03:17, 03:20, 03:23, 03:24, 03:28, and 03:30. At 03:31, we still could not confirm that the OBS had been enabled. Two more burn codes were sent at 03:32 and 03:34 before starting a continuous burn code at 03:34 at a distance of 1000 m from the OBS location. At 03:44, the ship was directly over the location. At 03:51, we were finally able to confirm that the OBS had been enabled and was off the seafloor. We estimated that the instrument would arrive on the surface at 06:30 UTC, or 23:30 local time. It actually arrived on the surface at 05:42 UTC, where it was seen and heard by the bridge at a distance of 1200 m southwest of the seafloor location. It was placed safely on deck at 05:56 at a surface location of 33° 58.805' N, 123° 50.832' W, and a depth of 4454 m. GPS synchronization was carried out at 06:01 UTC. Calculated rise rate: 40 m/min.

OBS Station 18

OBS station 18 was an LP T-240. Curie Ahn was the watchstander for the recovery of OBS18 with a local date and time of 09/12/11, 03:00 and Beaufort Sea State of 1-2. Kelsey Brunner took over at 04:00 local time. The true wind speed was 2.0 m/s and true wind direction 59.2°. On JD 254 at 09:59 UTC, the vessel was approximately 2000 m from the OBS location. The first enable code was sent at 09:59 UTC from a distance of 2600 m was immediately successful. This was followed by a burn code at 10:00 UTC. The bridge was asked to move over the seafloor location at 10:15 UTC because the first burn code was not successful. A second burn command was sent at 10:25 UTC and a third was sent at 10:40. At 10:59 UTC, we were able to determine that one of the burn codes was successful and the OBS was off the seafloor. Based on a depth of ~4700 m, we estimated that it would arrive on the surface at 13:00 (06:00 local time). The OBS was heard and spotted from the ship at 13:08. It was placed safely on deck at 13:24 at a surface location of 33° 167.764' N, 123° 51.942' W, and a depth of 4463 m. GPS synchronization was carried out at 13:30. The OBS time tag showed 13:30:57.4078700. Calculated rise rate: 35 m/min.

OBS Station 19

OBS station 19 was an LP T-240 sensor. Paige Logan was the watchstander for the recovery of OBS19. The local date and time was 09/12/11 and 10:21, respectively. At 17:17 UTC on JD 255, the vessel reached a distance of 1000 m from the OBS location. At 17:28 UTC, the vessel passed the original seafloor location. At 17:40 UTC, the OBS crew called the bridge and asked that the vessel be positioned directly over the seafloor location due to lack of communication with the instrument. The enable code was sent and the instrument was enabled at 17:21. The burn code was sent at 17:24 UTC. At 17:40 UTC, the OBS crew was unable to confirm the success of the first burn code, so a second burn code was sent. At 17:55 UTC, the OBS was still thought to be on the seafloor so a third burn command was sent. At 18:08 UTC, the burn code was confirmed successful and the OBS was off the seafloor. The estimated time of arrival on the surface was 20:15 UTC. At 20:16 UTC, the OBS was sighted from the ship with the RDF heard at approximately 20:12 UTC. OBS19 was safely on deck at 20:31 UTC with a surface latitude and longitude of 33° 18.396' N and 123° 02.187' W, respectively. The GPS time synchronization was carried out at 255:20:36:06.2836346 UTC. The depth of recovery was 4356 m with a wind speed of 2.7 m/s and wind direction of 4.9°. The Beaufort Sea State was a 3. Calculated rise rate: 35 m/min.

OBS Station 20

OBS station 20 was an LP T-240. Monica Kohler was the watchstander for OBS20 on 9/12/11. On JD 255 at 00:17 UTC, a series of burn commands was sent. The final burn code sent at 00:28 UTC was confirmed successful at 00:43 UTC. By 00:52 UTC, OBS20 was off the seafloor and its estimated arrival time on the surface was 03:00 UTC. The OBS was sighted and heard 30 minutes earlier than expected at a surface location of 34° 00.690' N and 123° 01.030' W. At 02:40 UTC OBS20 was on deck and its time tag displayed 02:50:58.3237698. The depth at the recovery site was 4297 m, true wind speed was 6.2 m/s and wind direction was 317.5°. The Beaufort Sea State was a 2. Calculated rise rate: 44 m/min.

OBS Station 21

OBS station 21 was an LP T-40 sensor. Paige Logan was the watchstander for OBS21. The local date and time of recovery was 09/12/11 and 22:59, respectively. On JD 256 at 06:17 UTC, the vessel reached a distance of 1000 m. Even before an enable code was sent, a series of burn codes was sent out at the following times: 05:56, 05:58, 06:02, 06:04, 06:06, 06:08, 06:11, and 06:14 UTC. These burn codes were purposely sent out early as we approached the OBS location, and at 06:29 UTC the burn was confirmed successful. At 06:32 UTC an enable code was sent and OBS21 was enabled right away. Its estimated arrival time on the surface was 08:45 UTC. At 08:25 UTC the bridge confirmed both visual and radio at a surface location of 34° 02.229' N and 122° 17.126' W. By 08:47 UTC, OBS21 was safely on deck and its OBS time tag showed 08:55:55.705305. The true wind speed was 4.8 m/s and wind direction 353.4°. The Beaufort Sea State was a 3. Calculated rise rate: 23 m/min.

OBS Station 22

OBS station 22 was an LP T-240 sensor. Kelsey Brunner was the watchstander for the recovery of OBS22, with a local date and time of 09/13/11 and 05:04, respectively. At 12:04 UTC on JD 256, the vessel was 2000 m from the OBS location. The enable code was sent successfully and the OBS was enabled at 12:05 UTC. At 12:06 UTC the burn code was sent, and success was confirmed at 12:21 UTC. Confirmation that the instrument was off the seafloor and rising was at 12:23 UTC with a surface ETA of 14:10 UTC, 07:10 local time. At 14:02 UTC, the OBS was sighted from the ship, and the RDF was heard two minutes prior to the sighting. The OBS was successfully and safely recovered onto the deck at 14:23 UTC, at a surface latitude and longitude of 34° 05.512' N and 121° 39.323' W. The GPS time synchronization was carried out at 14:36 UTC. The depth at the recovery site was 3565 m with a wind speed of 8.8 m/s and a wind direction of 327.1°. The Beaufort Sea State was a 4. Calculated rise rate: 37 m/min.

OBS Station 23

OBS station 23 was an LP T-240 sensor. Paige Logan was the watchstander for the recovery of OBS23, with a local date and time of 09/13/11 and 10:28, respectively. On JD 256 at 17:28 UTC, the vessel was 2000 m from the OBS location. The enable code was sent successfully and the OBS was enabled at 17:28 UTC. At 17:30 UTC the burn code was sent with success confirmed at 17:45 UTC. Confirmation that the instrument was off the seafloor and rising was at 17:48 UTC with a surface ETA of 18:50 UTC. At 18:44 UTC, both visual and radio observation of OBS23 was confirmed. The OBS was safely recovered onto the deck at 18:59 UTC at a surface latitude and longitude of 34° 08.938' N and 121° 05.074' W. The OBS time tag showed

19:06:01.2910106. The depth at the recovery site was 2029 m with a wind speed of 9.2 m/s and a wind direction 330.7°. The Beaufort Sea State was a 4. Calculated rise rate: 36 m/min.

OBS Station 24

OBS station 24 was an LP T-40 sensor. Kelsey Brunner was the watchstander for the recovery of OBS24 on September 13, 2011 at 16:25 local time. At 23:35 UTC on JD 256, we were 2000 m from the OBS location. An enable code was sent at 23:27 UTC from a distance of 1500 m and was successful on the first attempt. A burn code was then sent at 23:29 and it was also successful on the first try. We verified that the OBS was off the seafloor at 23:47 UTC. Based on a depth of ~3500 m, we estimated the surface arrival time to be at 01:30 on JD 257 or 18:30 local time. It was spotted from the ship on the starboard side at 01:52 UTC on JD 257. The OBS was recovered and safely placed on deck at 02:07 UTC at a surface location of 33° 26.346' N, 120° 51.745' W, and a depth of 3587.2 m. The water was rather rough with a Beaufort Sea State of 4-5 and winds of 11 m/s from 331.3°. The GPS synchronization was then carried out 02:10 UTC. Calculated rise rate: 29 m/min.

OBS Station 25

OBS station 25 was an LP T-240. Jennifer Zhu and Paige Logan were the watchstanders for the recovery of OBS25 on September 13, 2011 at 21:18 local time. At 04:27 UTC on JD 257, we were 2000 m from the OBS location. An enable code was sent at 04:38 UTC and was successful on the first attempt. A series of burn codes were then sent between 04:07 and 04:28 at roughly every two minutes. The burn was successful at 04:37 (we realized it was in the burn sequence at 04:31 UTC). We verified that the OBS was off the seafloor at 04:37. Based on a depth of ~1100 m, we estimated the surface arrival time to be 05:05 UTC or 22:05 local time. It was spotted from the ship (and the radio was heard) at 05:02. The OBS was recovered and safely placed on deck at 05:17 UTC at a surface location of 33° 31.399 N, 120° 27.833 W, and a depth of 1104.3 m. The water was rather rough with a Beaufort Sea State of 4 and winds of 9.2 m/s from 310.2°. The GPS synchronization was carried out at 05:24 UTC. Calculated rise rate: 44 m/min.

OBS Station 26

OBS station 26 was an SP L-28. Curie Ahn and Teddy Sotirov were the watchstanders for the recovery of OBS26, with a local date and time of 09/14/11 and 1:08, respectively. On JD 256 at 08:03 UTC, the vessel was approximately 2000 m from the OBS location. A series of burn commands was sent at the following times: 07:59, 08:00, 08:01, 08:02, and 08:07 UTC, and the 07:59 UTC burn command was confirmed successful at 08:13 UTC. At 08:13 UTC, OBS26 was enabled and was confirmed off the seafloor with an expected arrival time on the surface of 08:40 UTC. At 08:28 UTC, OBS26 was sighted and its radio heard from a surface location of 33° 14.925' N and 120° 02.057' W. At 08:45 UTC, OBS26 was on deck and its time tag showed 08:5 31.294 UTC. The depth at the recovery site was 2029 m with a wind speed of 6.6 m/s and a wind direction 304.2°. The Beaufort Sea State was a 4. Calculated rise rate: 62 m/min.

OBS Station 27

OBS station 27 consisted of an SP L-28. Kelsey Brunner, Jennifer Zhu, and Paige Logan were the watchstanders for the recovery of OBS27 on September 14, 2011 at 7:53 local time. OBS27 was recovered after OBS28. At 14:56 UTC on JD 257, we were 2000 m from the OBS location. Enable codes were sent at 14:53, 14:55, and 14:56 UTC, with success at 14:56 UTC. A burn code was sent at 14:57 and was deemed successful at 15:13, which was also when we verified that the OBS was off the bottom. Based on a depth of ~1900 m, we estimated the surface arrival time to be 15:45 (or 8:45 local time). It was spotted from the ship (and the radio was heard) at 15:43 UTC. The OBS was recovered and safely placed on deck at 05:51 at a surface location of 33° 44.572' N, 119° 35.674' W, and a depth of 1921.6 m. The Beaufort Sea State was a 2 and there were winds of 4.6 m/s from 294.5°. The GPS synchronization was carried out at 16:05:02. Calculated rise rate: 48 m/min.

OBS Station 28

OBS station 28 consisted of an LP T-240 sensor. Kelsey Brunner was the watchstander for the recovery of OBS28 on September 14, 2011 at 05:22 local time. Note that OBS28 was recovered before OBS27. At 12:22 UTC on JD 257, we were 2000 m from the OBS location. An enable code was sent at 12:23 UTC and was successful on the first try. A burn code was sent at 12:24 UTC and was also successful on the first attempt. We determined that the instrument was off the seafloor at 12:40 UTC. We estimated that it would arrive on the surface at 13:35 UTC, or 6:35 local time. It was spotted on the surface at 13:29 UTC and heard shortly thereafter. OBS28 was safely placed on deck at 13:39 UTC at a surface location of 33° 32.688' N, 119° 27.716' W, and a depth of 1855.4 m. There was a small amount of mud found on the feet of the instrument and there was a sea slug attached to the sensor ball. The Beaufort Sea State was a 2, with a wind speed of 4.3 m/s from 293.5°. The GPS was synchronized at approximately 13:45 UTC. Calculated rise rate: 38 m/min.

OBS Station 29

OBS station 29 was an SP L-28. Jennifer Zhu and Paige Logan were the watchstanders for the recovery of OBS29 on September 14, 2011 at 10:41 local time. At 17:41 UTC on JD 257, we were 2000 m from the OBS location. An enable code was sent at 17:44 UTC and was successful on the first try. A burn code was then sent at 17:44 UTC and was successful at 18:04 UTC on the first attempt. We determined that the instrument was off the seafloor at 18:04 UTC. We estimated that it would arrive on the surface at 18:14 UTC, or 11:14 local time. It was spotted on the surface at 18:13 UTC. OBS28 was safely placed on deck at 18:19 UTC at a surface location of 33° 52.622' N, 119° 16.303' W, and a depth of 827.6 m. The Beaufort Sea State was a 2, with a wind speed of 4.3 m/s from 293.5°. The GPS was synchronized at approximately 13:45. Calculated rise rate: 38 m/min.

OBS Station 30

OBS station 30 was an SP L-28. Teodor Sotirov was the watchstander for the recovery of OBS30, with a local date and time of 09/14/11 and 13:35, respectively. On JD 257 at 20:31 UTC, the vessel was approximately 2000 m from the OBS station. A series of burn commands was sent at the following times: 20:24, 20:26, 20:28, 20:31, and 20:34 UTC, and the first burn was confirmed successful at 20:39 UTC. At 20:41 UTC, an enable code was sent and OBS30 was enabled right away. By 20:45 UTC, the OBS crew had confirmation that the OBS was off the seafloor with an estimated arrival time of 21:05 UTC. The OBS was seen and heard at 21:00 UTC and was safely recovered on deck at 21:04 UTC. Its surface location at recovery was 33° 43.239' N, 118° 52.504' W, and its depth 913 m. The OBS time tag displayed 21:12:21.8146837.

The Beaufort Sea State was a 1, true wind speed was 0.7 m/s, and true wind direction was 203.7°. Calculated rise rate: 61m/min.

OBS Station 31

OBS station31 consisted of an SP L-28. Kelsey Brunner was the watchstander for the recovery of OBS31 on September 14, 2011 at 16:23 local time. At 23:23 UTC on JD 257, an enable code was sent from a distance of 3500 m. Burn codes were then sent at 23:27 and 23:29 UTC. These were all deemed successful at 23:30 UTC and we confirmed that the instrument was off the seafloor at 23:45 UTC. It was estimated to arrive on the surface between 23:55 and 00:00 UTC on JD 258. It was spotted from the ship at 23:51 UTC and was on deck by 00:03 UTC. It was recovered at a surface location of 33° 33.107' N, 118° 25.123' W, and a depth of 904.4 m. GPS synchronization was carried out at 00:05 UTC.

OBS Station 32

OBS station 32 consisted of an LP T-240 sensor. Curie Ahn and Teodor Sotirov were the watchstanders for the recovery of OBS32 on 9/16/11 at 01:20 local time. On JD 259 at 08:18 UTC, the vessel was approximately 2000 m from the OBS location. At 08:20 UTC, an enable code was sent and the OBS was enabled right away. The first burn command sent at 08:22 UTC was confirmed successful 15 minutes later at 08:38 UTC. By 08:38 UTC, OBS32 was off the seafloor and its estimated time on the surface was 08:47 UTC. At 09:09 UTC, the OBS was sighted from the ship and it was safely recovered on deck at 09:21 UTC from a surface location of 33° 11.893' N and 118° 25.957' W. The OBS time tag showed 09:20:00.6923748 and depth at the recovery site was 1268 m. True wind speed was 4.3 kts and wind direction 93°. The Beaufort Sea State was a 1. Calculated rise rate: 40.9 m/min.

OBS Station 33

OBS station 33 was an SP L-28. Curie Ahn and Kelsey Brunner were the watchstanders for OBS33. The local date and time was 09/16/11 and 03:38, respectively. The vessel was 2000 m from the OBS location at 11:00 UTC on JD 259. The enable code was sent successfully at 10:47 UTC and was enabled at 11:03 UTC. The burn code was sent twice, at 11:07 and 11:08 UTC, and was successfully confirmed at 11:25 UTC, which is also the time the instrument began its rise from the seafloor. The ETA to the surface was 11:45 UTC but was spotted from the ship at 11:40 UTC. The instrument was successfully and safely placed on deck at 11:51 UTC. The OBS was recovered at a surface latitude and longitude of 33° 08.004' N and 118° 09.121' W, respectively. The GPS time synchronization was carried out at 11:57 UTC. The depth of recovery was 1057.7 m with a wind direction and speed of 2.8 kts and 262.3° respectively. Calculated rise rate: 70.5 m/min

OBS Station 34

OBS station 34 consisted of an SP L-28. Kelsey Brunner was the watchstander for the recovery of OBS34. The local date and time was 09/16/11 and 06:54, respectively. At 13:54 UTC on JD 259, the vessel was 2000 m from the OBS location. The enable code was sent at 13:54 UTC. The instrument was enabled at 13:58 UTC with two burn codes sent at 13:55 and 13:58 UTC with the last burn command proving successful. OBS34 was confirmed to be rising from the seafloor at 14:14 UTC and it reached the surface at 14:30 UTC. The instrument was safely recovered and placed on deck at 14:40 UTC with a surface latitude and longitude of 32° 56.259' N and

117° 49.217' W, respectively. The depth of the recovery site was 1039.6 m. The GPS time synchronization was completed at 14:45 UTC. The wind speed and direction during recovery was 4.6 kts and 172.3 °. The Beaufort Sea State was a beautiful 1. Calculated rise rate: 64.9 m/min

Horizontal orientations

When the OBSs are dropped, their horizontal orientation is not known until subsequent data analysis is performed using earthquake data. The horizontal component orientations for each operational seismometer were determined using surface wave analysis. The horizontal component waveforms are rotated until the Rayleigh wave amplitude is maximized and associated with the known back azimuth. This analysis assumed that channel 0 was 90 degrees east of channel 1 (for whatever direction channel 1 had landed on the seafloor). We have determined that this is the only possible configuration; the opposite case is not possible with the given earthquake data we have looked at. But in a few cases it appears that this convention is reversed (see OBS02 and OBS31). We believe this is just a wiring issue for the SIO techs. Many earthquakes were examined for each station to determine the orientations. Specifically, we required that at least three earthquakes from widely different back azimuths should all produce the same result within the error (see errors in Std. Dev. Column in Table 2). The short-period instruments were more difficult to work as a result of their large frequency cutoff; thus they have larger errors.

Table 1 (next page). Instrumentation and time details for each station.

OBS Drop #	**Instru-ment Type**	**LAT** Relocated	**LON** Relocated	**Depth** (m)	**Time in Water** UTC jday:hr:min	**Time on seafloor** UTC jday:hr:min	**GPS Synch Time at Deployment** UTC jday:hr:min:sec	**Wake Time** UTC jday:hr:min:sec	**GPS Synch Time at Recovery** UTC Jday:hr:min:sec	**Clock Drift over Total Recording Period** (seconds)
1	SP	32 37.2761	-118 8.8229	2043	226:23:38	227:00:21	226:22:41:00	227:08:00:00	2011:250:21:58:00.5020528	0.5020528
2	SP	32 48.7081	-118 48.2175	1451	227:04:52	227:05:22	227:00:07:00	227:20:00:00	2011:251:02:46:00.5390425	0.5390425
3	LP	33 0.7726	-118 57.4432	1730	227:07:43	227:08:19	227:01:38:00	228:17:00:00	2011:251:05:49:57.9972527	-2.002748
4	LP	33 19.1232	-119 10.9694	1051	227:11:10	227:11:31	227:06:21:00	228:22:00:00	Stuck-Responding	
5[1]	SP	33 5.2220	-119 18.0102	1617	227:13:33	227:14:06	227:08:27:00	229:00:00:00	2010:238:17:15:00.0270108	0.0270108
5[2]	SP	33 5.2358	-119 17.8581	1616	238:17:41	238:18:14	238:17:24:00	239:00:00:00	2011:251:24:22:00.7627667	0.7627667
6	LP	32 46.6192	-119 51.4677	1169	227:17:59	227:18:21	227:13:54:00	228:10:00:00	2011:251:18:39:58.9504275	-1.049573
7	LP	32 44.5327	-120 43.5905	3769	228:11:19	228:12:35	228:03:10:00	230:05:00:00	2011:252:02:29:58.995202	-1.004798
8	LP	32 39.2710	-121 20.5525	3888	228:16:55	228:18:17	228:11:37:00	229:21:00:00	2011:252:08:53:58.5463084	-1.453692
9	LP	33 24.5183	-121 30.4322	3819	229:00:19	229:01:38	228:17:15:00	230:00:00:00	2011:252:17:02:59.8691500	-1.13085
10	LP	33 18.6516	-122 11.7082	3777	229:05:54	229:07:10	229:00:07:00	230:11:00:00	2011:253:00:24:57.5186149	-2.481386
11	LP	32 39.8715	-122 18.0960	4185	229:11:53	229:13:19	229:06:13:00	230:18:00:00	2011:253:06:58:00.8943059	0.8943059
12	LP-T40	32 38.6871	-123 5.2956	4098	228:18:36	229:19:56	229:12:25:00	230:18:00:00	2011:253:14:21:00.6981427	0.6981427
13	LP	32 39.3025	-123 49.7155	4281	230:01:08	230:02:31	221:19:51:00	230:21:00:00	2011:253:21:28:59.5998144	-0.400186
14	LP	32 38.1503	-124 37.9369	4374	230:07:57	230:09:30	230:01:04:00	231:22:00:00	Not Responding	Abandon
15	LP	33 18.9424	-124 38.8298	4248	230:15:18	230:16:44	230:08:14:00	231:18:00:00	2011:254:16:23:58.9461029	-1.053898
16	LP	34 0.6851	-124 38.3059	4552	231:03:21	231:04:51	230:15:45:00	231:13:00:00	2011:254:23:45:56.3124593	-3.687541
17	LP	33 59.2225	-123 50.4051	4426	231:10:15	231:11:48	231:03:37:00	232:03:00:00	2011:255:06:01:00.8788115	0.8788115
18	LP	33 17.9964	-123 52.1074	4461	231:21:57	231:23:31	231:10:34:00	233:00:00:00	2011:255:13:30:57.4078700	-2.59213
19	LP	33 18.1281	-123 2.2397	4374	232:04:53	232:06:25	231:22:21:00	233:03:00:00	2011:255:20:35:00.2836437	0.2836437
20	LP	34 0.6596	-123 1.9558	4293	232:12:10	232:13:39	232:05:17:00	233:17:00:00	2011:256:02:50:58.3237690	-1.676231
21	LP-T40	34 1.9705	-122 17.1759	3876	232:18:19	232:19:37	232:14:14:00	234:00:00:00	2011:256:08:55:55.705305	-4.294695
22	LP	34 5.8675	-121 39.7047	3562	232:23:29	233:00:43	232:19:41:00	235:00:00:00	2011:256:14:30:55.7386586	-4.261342
23	LP	34 8.9088	-121 5.1738	2010	233:04:19	233:05:00	232:23:51:00	234:00:00:00	2011:256:19:06:01.2910106	1.2910106
24	LP-T40	33 26.5622	-120 51.5388	3571	233:09:46	233:10:58	233:04:43:00	234:10:00:00	2011:257:02:10:58.4028085	-1.597192
25	LP	33 31.3971	-120 27.5800	1093	234:11:14	234:11:40	233:10:17:00	235:10:00:00	2011:257:05:24:57.9827078	-2.017293
26	SP	33 15.0195	-120 1.9883	922	234:22:15	234:22:38	234:12:31:00	236:00:00:00	2011:257:08:53:59.2943082	-0.705692
27	SP	33 44.8495	-119 35.5395	1894	236:04:18	236:04:59	234:22:28:00	236:22:00:00	2011:257:16:05:02.9618704	2.9618704
28	LP	33 32.5962	-119 27.8688	1832	236:10:03	236:10:42	236:05:25:00	238:10:00:00	2011:257:13:45:59.4862527	-0.513748
29	SP	33 52.6342	-119 16.2139	819	236:13:17	236:13:38	236:10:19:00	237:10:00:00	2011:257:18:28:59.3714595	-0.628541
30	SP	33 43.0203	-118 52.3753	901	236:21:05	236:21:24	236:13:35:00	237:13:00:00	2011:257:21:11:57.2791542	-2.720846
31	SP	33 33.0174	-118 25.0643	896	237:01:30	237:01:50	236:21:54:00	237:01:00:00	2011:258:00:09:59.9953834	-0.004617
32	LP	33 12.5101	-118 28.8103	1248	237:14:30	237:14:55	237:02:04:00	238:21:00:00	2011:259:09:29:00.6923748	0.6923748
33	SP	33 7.9721	-118 9.0874	1044	237:17:33	237:17:59	237:16:19:00	238:15:00:00	2011:259:11:58:59.4560983	-0.543902
34	SP	32 56.0838	-117 49.0863	1025	237:20:19	237:20:41	237:17:57:00	238:17:00:00	2011:259:14:49:00.8044757	0.8044757

Table 2. Horizontal component orientations resulting from surface wave analysis.

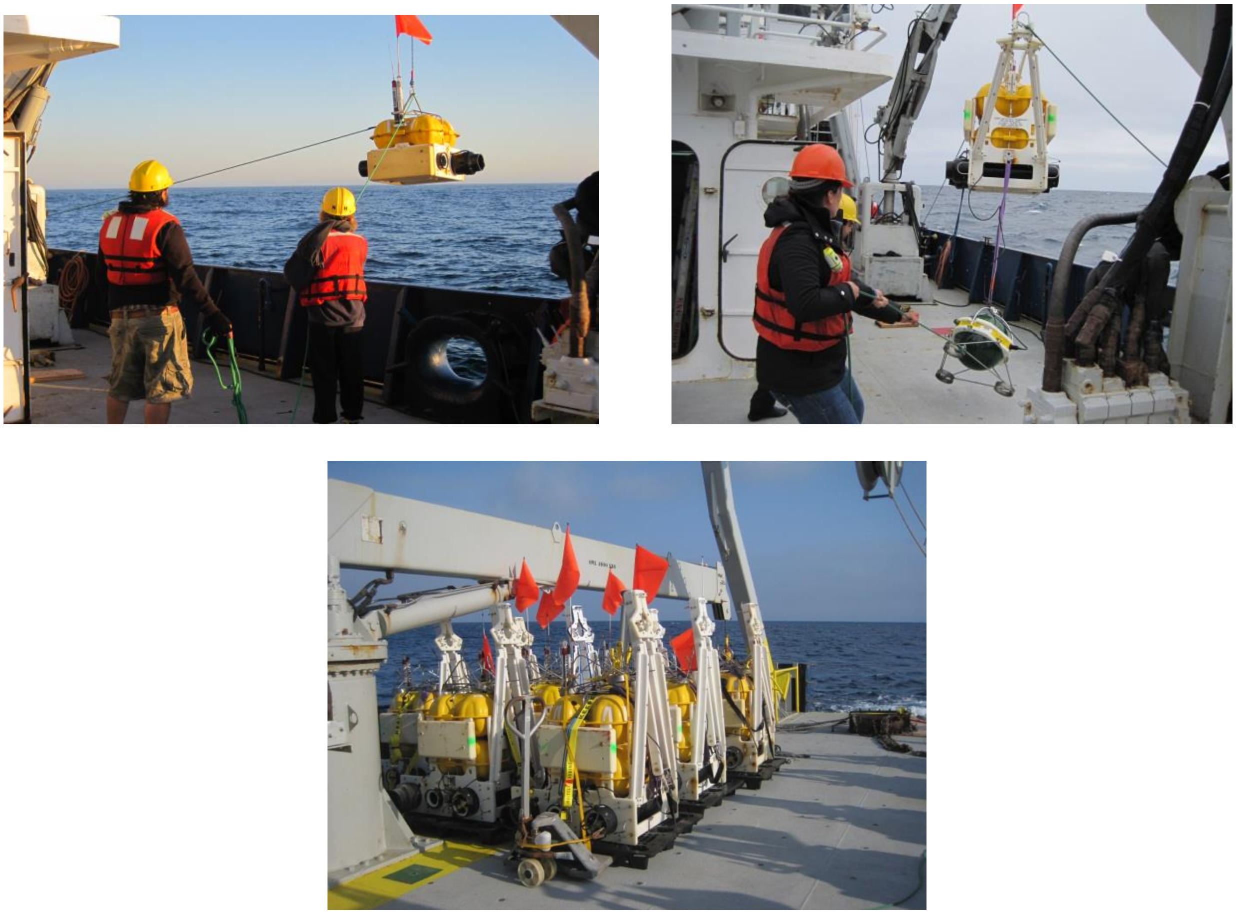

Figure 3. Recovery of a short-period OBS (top left) and long-period OBS (top right). OBSs were stored on the main deck after recovery (bottom).

OBS Rise Rate plots

Rise rates for the instruments indicate that there is a dependence on the depth of the deployment. Greater depths show lower average rise rates (Table 3; Figs. 4-6). In addition, OBSs with low rise rates may have initially been stuck in seafloor mud because several had mud stuck to the OBS feet, observed they were recovered and placed on deck.

Table 3. OBS rise rates as a function of depth for long-period (LP) and short-period (SP) OBSs.

All OBSs				Short-period OBSs			Long-period OBSs		
OBS #	Depth (m)	Rise Rate (m/min)	Inst. Type	Short-periods only (OBS #)	Depth (m)	Rise Rate (m/min)	Long-periods only (OBS #)	Depth (m)	Rise Rate (m/min)
1	2062	53	SP	1	2063	53	3	1746	44
2	1450	58	SP	2	1450	58	6	1181	54
3	1746	44	LP	5	1630	37	7	3773	29
5	1630	37	SP	26	933	62	8	3900	39
6	1181	54	LP	27	1922	48	9	3810	37
7	3773	29	LP	29	828	92	10	3708	29
8	3900	39	LP	30	913	70	11	4196	33
9	3810	37	LP	31	904	150	12	4124	27
10	3708	29	LP	33	1058	71	13	4281	26
11	4196	33	LP	34	1070	65	15	4260	32
12	4124	27	LP				16	4565	49
13	4281	26	LP				17	4454	40
15	4260	32	LP				18	4436	35
16	4565	49	LP				19	4356	35
17	4454	40	LP				20	4297	44
18	4436	35	LP				21	2565	23
19	4356	35	LP				22	3565	37
20	4297	44	LP				23	2029	36
21	2565	23	LP				24	3587	29
22	3565	37	LP				25	1104	44
23	2029	36	LP				28	1855	38
24	3587	29	LP				32	1268	41
25	1104	44	LP						
26	933	62	SP						
28	1855	38	LP						
27	1922	48	SP						
29	828	92	SP						
30	913	70	SP						
31	904	150	SP						
32	1268	41	LP						
33	1058	71	SP						
34	1070	65	SP						

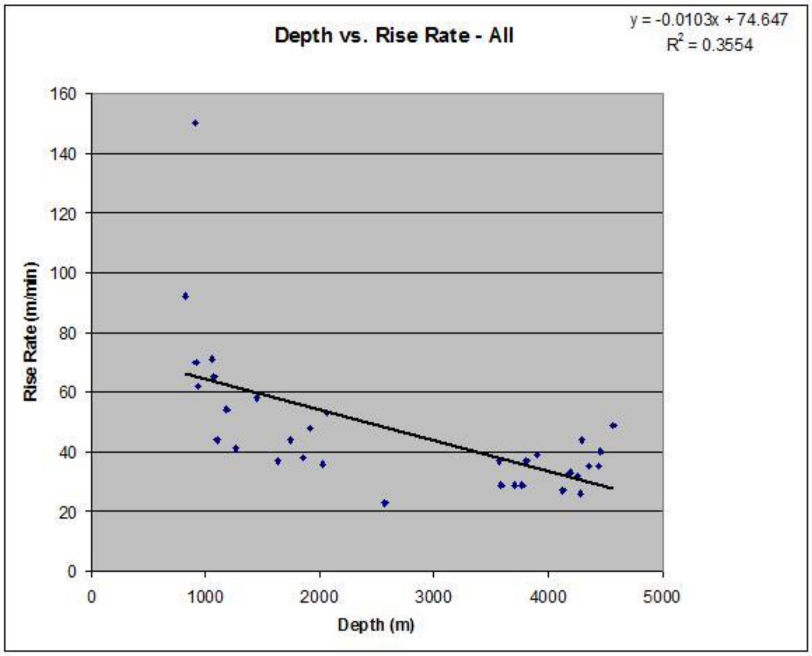

Figure 4. OBS rise rates as a function of depth for all OBSs (both long-period and short-period).

Short-period instruments had lower rise rates averaging approximately 40 m/min (Fig. 5). Long-period OBSs rose at an average of 60 m/min (Fig. 6).

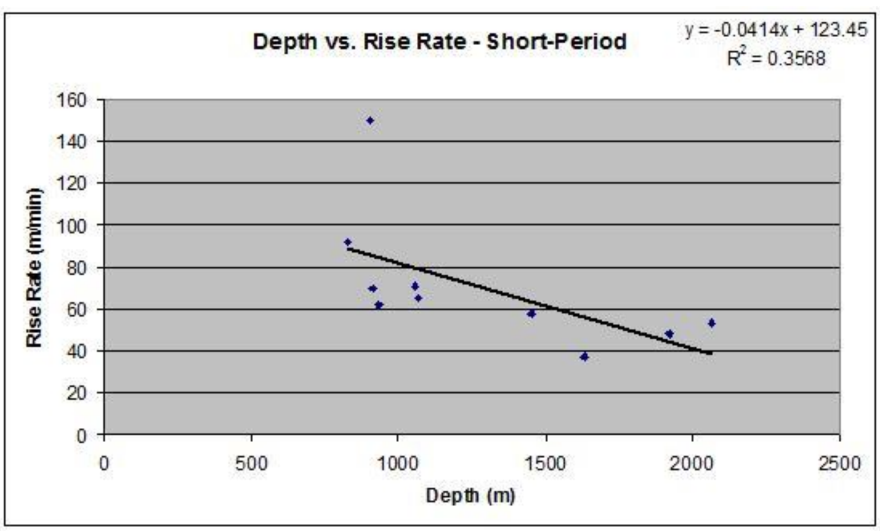

Figure 5. OBS rise rates as a function of depth for short-period (SP) OBSs.

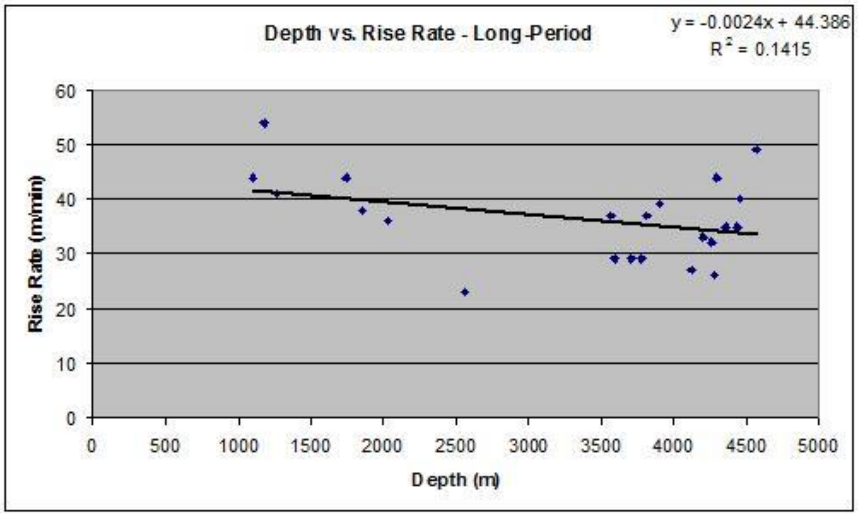

Figure 6. OBS rise rates as a function of depth for long-period (LP) OBSs.

Data Quality Notes

Observations specific to individual OBSs are as follows.

<u>OBS01: SIO L-28</u>

Channel 1 flat-line dead for days 2010:227-257. Channel 1 zeroed at 8.8×10^6 counts. Square wave function before channel 1 kicks into life on day 257. Signal mean is 4×10^6.

Channel 2 has harmonic spikes (60-second intervals for each up spike, alternating with 60-second-interval down spikes that are 30 seconds out of phase with up spikes) on channel 2.

After 257, channel 1 has spikes at exactly the same times as, and exactly in phase with, channel 1.

Day 2011:014: square wave in channel 1. Channel 1 dies (zeroed at 8.8×10^6), then comes to life again later that same day.

Day 2011:046: square wave in channel 1. Channel 1 dies again (zeroed at 8.8×10^6), then comes to life again on day 051.

Channel 1 dead again on day 057 but exhibits random spikes. Back to life on 076.

Channel 0 seems to be OK entire 12 months.

<u>OBS02: SIO L-28</u>

All channels OK overall, entire 12 months.

<u>OBS03: SIO T-240</u>

All channels OK overall, entire 12 months.

<u>OBS04: SIO T-240</u>

Not recovered. Successful enable command sent but no successful burn/release. Went back to try to recover with two dredge/drag attempts during the same cruise, both of which were unsuccessful.

OBS05: SIO L-28
All channels OK overall, entire 12 months.

OBS06: SIO T-240
All channels OK overall, entire 12 months.

OBS07: SIO T-240
All channels OK overall, entire 12 months.

OBS08: SIO T-240
All channels OK overall, entire 12 months.

OBS09: SIO T-240
Seismometer channels 0 and 2 are bad entire 12 months. Single-digit bit-level recordings. Bad channel 0 still shows larger-amplitude but contaminated response to 03/11/11 Honshu earthquake.

OBS10: SIO T-240
All channels OK overall, entire 12 months.

OBS11: SIO T-240
All channels OK overall, entire 12 months.

OBS12: SIO T-40
Seismometer channels 0-2 bad entire 12 months. Single-digit bit-level recording.

OBS13: SIO T-240
All channels OK overall, entire 12 months.

OBS14: SIO T-240
Never recovered.

OBS15: SIO T-240
All channels OK overall, entire 12 months.

OBS16: SIO T-240
Seismometer channels 0-2 bad entire 12 months. During some multi-day periods, channels 0-2 recorded at large count values (10^6) as if nearly clipped but within small range. Then during other multi-day periods, they recorded at single-digit bit-level recordings also within small range. Then went back again to large count values but within small range.

OBS17: SIO T-240
All channels OK overall for first 4 months, except that seismometer channels 0-2 show short impulse-like peaks at around 79,000 seconds every 7 days. Re-leveling effects on vibration response?

All seismometer channels went bad on 2011:017. 3/11/11 Tohoku earthquake shows up weakly above low bit-level recording. Maybe gimbal clamps failed, OBS continued to rock back out of level. Maybe went into leveling loop where it slowly ate up battery and had only a little power left. Level enough to record something on 2 channels?

<u>OBS18: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS19: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS20: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS21: SIO T-40</u>
All channels OK overall, entire 12 months.

<u>OBS22: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS23: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS24: SIO T-40</u>
All channels OK overall, entire 12 months.

<u>OBS25: SIO T-240</u>
All seismometer channels 0-2 dead entire 12 months. Single-digit bit-level records.

<u>OBS26: SIO L-28</u>
All channels OK overall, entire 12 months.

<u>OBS27: SIO L-28</u>
All channels OK overall, entire 12 months.

<u>OBS28: SIO T-240</u>
All channels OK overall, entire 12 months.

<u>OBS29: SIO L-28</u>
All channels OK overall, entire 12 months.

<u>OBS30: SIO L-28</u>
All channels OK overall, entire 12 months.

<u>OBS31: SIO L-28</u>
All channels OK overall, entire 12 months.

OBS32: SIO T-240
All channels OK overall, entire 12 months.

OBS33: SIO L-28
All channels OK overall, entire 12 months.

OBS34: SIO L-28
All channels OK overall, entire 12 month

Subsequent hardware testing at SIO OBSIP lab revealed that for OBS09 there was intermittent failure of the cable to the outside world (this sensor had worked fine in the lab prior to the experiment). OBS12 lost power 12 hours into the deployment due to a worn connector socket. This was likely the same problem as with OBS09. OBS16 had a failure of the clamp motor of the gimbal system in the pressure case. As a consequence, the gimbal system tried continuously to level the sensor, and the sensor masses railed the entire time. OBS17 had a failure of the mass motor within the seismometer itself so that the mass railed the entire time. This seismometer was sent back to Nanometrics for repairs. In OBS25, the wiring within the sensor ball was broken and the sensor never powered up. The suspicion is that the wiring broke upon impact on the ocean floor.

General transducer observations from waveform examination are that channel 2 appears to be the vertical component for all OBSs. The consistent presence of larger-amplitude low-frequency noise was used to distinguish horizontal channels from the lower-amplitude vertical channel. Clock drifts vary between a fraction of a second to 4.3 seconds (Table 1). The hydrophones/DPGS appear to have recorded at all stations. Of the 32 recovered stations, 15 Borderland stations were low-pass FIR filtered at 4 Hz by Navy-contracted personnel during the recovery cruise for immediate analysis. We received the redacted, full-band data set in January, 2012. The short-period L-28s exhibit the previously-reported lack-of-shielding twisted pair cable noise problem at ~6.5 and 13 Hz (Dunn, 2010). This was already known to exist in our experimental data from several days of data downloaded from OBS05 during our 2010 OBS deployment cruise.

Dredges

Two dredge operations were attempted to recover OBS04 after the initial recovery effort was unsuccessful. Neither of them resulted in the recovery of OBS04. After picking up OBS31, we went back to OBS04 for the dredge-aided recovery. We had hoped to pick it up by dragging/dredging around the OBS seafloor location site in hopes of loosening up the sediment so that the OBS could break free. On JD 258 at 03:44 UTC, we discussed with the bridge our plan to conduct a survey around the instrument, starting from the northern point and heading in a counter-clockwise manner at less than 5 knots. We enabled the OBS successfully at 04:03 UTC on JD 258. While we were approaching the northern point, we were getting good slant ranges. After finishing the survey at 04:32 UTC, we approached the central point (i.e., OBS location) at a slower speed to send a few more ranges while we waited for dragging to start at midnight (we had to obtain special permission from the U.S. Navy to dredge only during a 48-hour period starting at midnight local time on September 15. The slant ranges were used to calculate a more accurate location of the OBS.

The dragging technique consisted of using the chain with hooks at the bottom of the dredge wire. The ship was driven in a circle as the wire was paid out, and the chain and hooks were placed on the seafloor around the OBS. We made approximately 1.5 loops around the site, with the ship circle at least twice the diameter that we expected the loop of chain to take on the bottom. After making the circle, we moved the ship a bit off the circle (a couple of circle diameters or more away) and then parked the ship as the wire was pulled in. The range to the transponder was monitored to determine whether the OBS had been lassoed.

The first attempt to drag up OBS04 was led by Resident Technician Meghan Donohue, starting around 07:30 UTC on JD 258 (09/15/2011). Just after midnight, a series of burn commands was continuously sent while the crew was laying out the wires on deck (the U.S. Navy also did not let us send any acoustic signals prior to midnight). At this point, no watchstanders were allowed on deck for physical safety reasons and were asked to simply monitor the amount of wire let out and tension of the wires. Meanwhile, several crew members were setting up a deployment bucket near the stern A-frame of the ship. The bucket was designed to drag along the bottom of the seafloor, and three weights and grapple hooks each separated by 10 m near the end of the wire were added to keep the bucket at the bottom. By 08:30 UTC, the deployment of the wire, bucket and weights was complete and Meghan came into the main lab to make further calculations. At 23:00 UTC, the ship was in a comfortable position to drag a second time. At 00:56 UTC on JD 259, a burn command was sent, but it was apparently not successful. At 01:20 UTC, we told the bridge to conduct another survey around the new position at 4 knots at 500 m clockwise. The survey started at 01:24 UTC. On day 259 at UTC 03:58, we headed back to the OBS after an unsuccessful dredge to record the location and disable it. At 04:15, the depth of the updated OBS location was recorded as 1059 m, and the final survey (clockwise) was conducted. The survey was completed at 04:39 UTC, and the OBS was successfully disabled at 04:40, at which point we headed to OBS 32 for the next recovery. Note that the OBS did not move from its original position, despite both dredging efforts.

The first dredge activity returned a few rock samples (Fig. 7). The dredge chain bag was 50% full of a very thick mud. We labeled this dredge #1 and saved a few rock samples which were recovered from the mud. One rock appears to be basalt with fairly well-rounded edges. A few samples appear to be other substances, perhaps petroleum, wood, metal, or other unidentified material

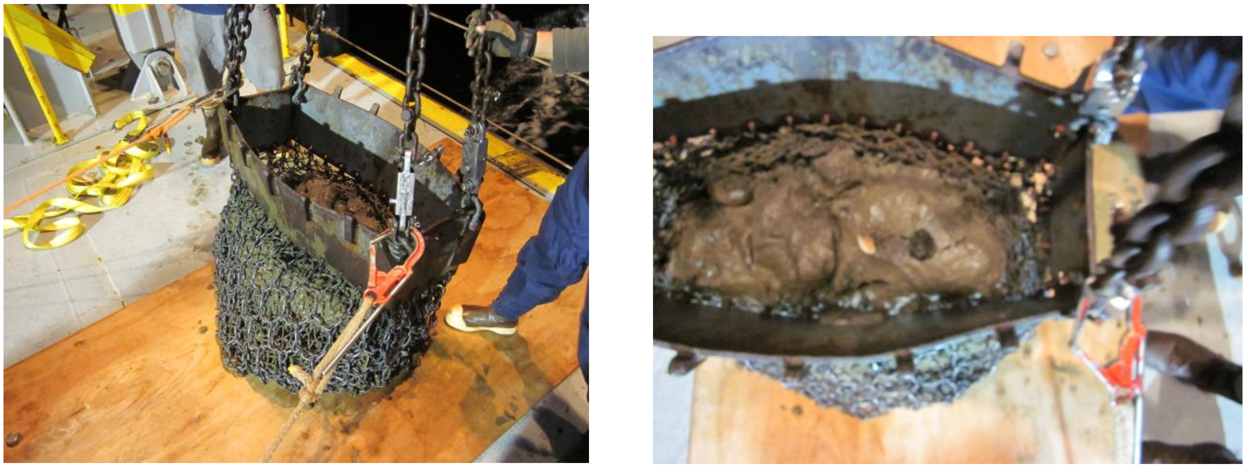

Figure 7. Dredge bag containing fine mud and rock samples collected from around the OBS04 location of 33° 19.12' N, -119° 10.97' W, and depth of approximately 1200 m.

Biological life

Some biological life was found on the instrumentation when we recovered the OBSs. We saw several varieties of tiny lobsters, crabs, and grass fibers (Fig. 8). Most were small, about the size of a thumb nail. One large crab was recovered from OBS32 that was larger (see Mark Gibaud's head for scale in Fig. 8) and was returned to the sea.

Figure 8. Crabs and lobsters found on OBSs after recovery. Left two are about one inch long.

C. Underway Geophysical Data

Echosounder Sub-bottom Profiler

New Horizon's echosounder system consisted of a Knudsen3260 3.5 kHz system and provided information about the depth and sediment conditions on the seafloor. The echosounder was synchronized with the ship's navigation system and was used throughout the entire cruise. Echosounder data was especially important when we had difficulty communicating with or recovering an OBS. It gave estimates of the gradient, sediment thickness, morphology, etc. of the original drop site which allowed us to infer why we may be having difficulty communicating with the instrument. For example, thick sediments imaged by the echosounder around an area where an OBS had trouble rising off the bottom suggested that the OBS may be stuck in those sediments. The echosounder was turned off during times we had issues communicating with the OBS in order to eliminate any possible acoustic noise interference.

The Knudsen system consists of 16 transducers placed in a grid pattern under the ship. It sends out sound waves and as the sound waves reflect off the ocean floor, it measures the returning waves as a function of time. It converts the time to depth in meters assuming that the speed of sound in water is 1500 m/s. When the echosounder is used over shallow waters, there is sometimes a second, artifact seafloor layer seen at twice the depth of the actual sea floor. This is due to the sound wave reflecting off the ship back down to the seafloor and then back up again to the receivers. The parameters of the echosounder that the watchstanders and computer technician changed according to local conditions throughout the cruise were:

- Tx Pulse: Measured in milliseconds, the Tx pulse describes the length of the sound bit being transmitted by the transducers. The Tx pulse ranges from 0.0625 ms to 64 ms. A higher Tx pulse corresponds to a stronger return. For most of this cruise, the Tx pulse was under 10 ms.

- Tx Power: Tx power corresponds to the power level of the transmitted pulse. Tx power ranges from 1 to 4 with 4 being the maximum power. A higher power also results in a stronger return.

- Gain Value: The gain value can only be controlled when the echosounder is set to the manual gain mode. The gain value controls the analog gain of the incoming data. The gain ranges from 0 dB to 96 dB; on this cruise the gain was set to below 15 dB. A higher gain created a darker echosounder image.

- Process Shift: The process shift controls the digital gain. It amplifies the data but it does not clip the analog data. It ranges from 0-13. For most of the cruise, the process shift was set to below 5. A higher process shift also resulted in a darker echosounder image. Reducing the process shift often significantly reduced the noise in the image.

- Range: This is the length of the water column below the echosounder that will be checked. For example, if the range is set to 500, the echosounder would only collect data for a select 500 meters.

- Phase: The phase can be set to auto or manual mode. For most of the cruise, the phase was set to manual mode since the auto mode had not yet been fully tested. The phase value sets the minimum and maximum depths for the water column.

- Depth limits: The depth limits (minimum and maximum) are the limits in which the phase can be set.

Once the completed echosounder files were stored to disk at a rate of approximately one per day, they could be viewed using the SounderSuite PostSurvey (v. 2.2) software. PostSurvey allows for the cutting of the file into time segments that correspond to regions of interest, such as the OBS locations. Additionally, an especially useful tool was the digitized curve display option. This option displays red dots that show the true depth recorded at each time point which allowed us to more clearly distinguish true seafloor depth from artifacts in the echosounder data. Note that in order to make accurate depth measurements, a correction to speed of sound for average ocean profiles specific to our deployment region needs to be made in post-cruise post-processing. The values of these corrections can be found in the Matthews Tables.

Below are a few examples of Echosounder images from the cruise (Figs. 9-11):

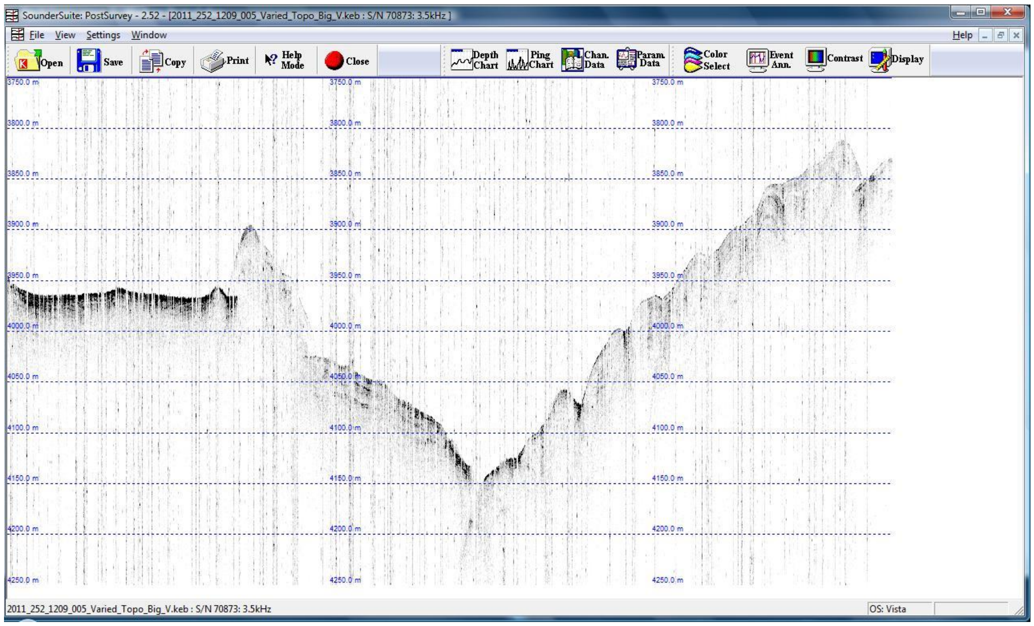

Figure 9. This image shows thin sedimentary layers showing jagged features from Julian day 252 from 18:48:02 to 20:53:18 UTC time. It covers the area between 33 22.02095 N/121 47.82990 W and 33 18.37395 N/122 11.43997 W. This places it a little south of OBS09, near some small seamounts and the Arguello Fracture Zone.

Figure 10. This image shows thin sedimentary layers from Julian day 251 from 03:53:05 to 05:00:49 UTC time. It covers the area between 32 58.35480 N/ 118 55.56061 W and 33 00.25314 N/118 56.91193 W. This places it near OBS03 in the Inner Borderland west of San Clemente Island and south of the San Nicolas Escarpment.

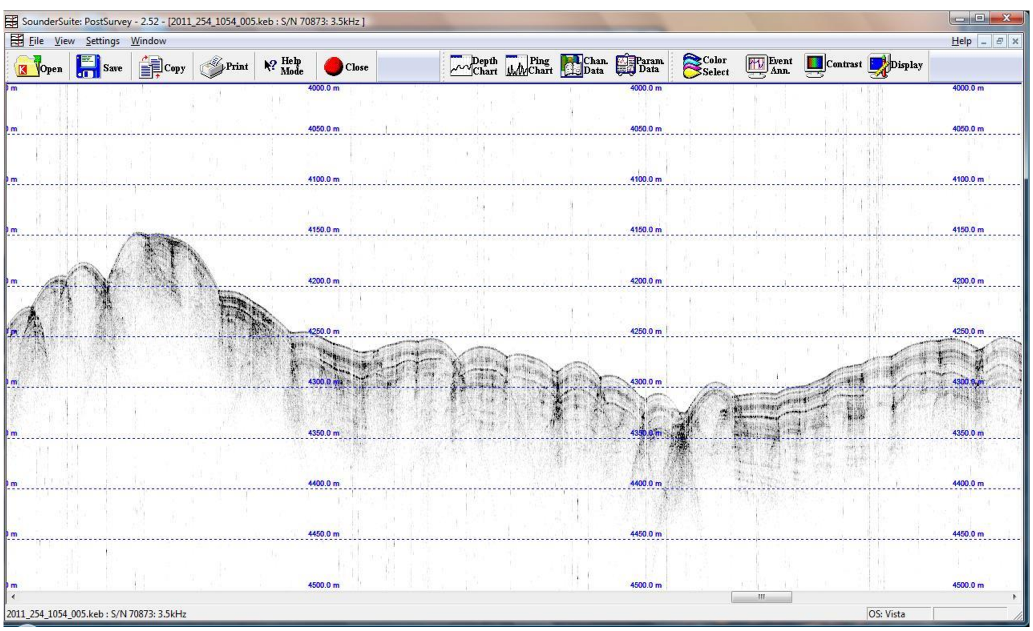

Figure 11. This image shows moderately thick sedimentary layers in the rounded topography from data recorded on Julian day 255 from 01:50:08 to 03:06:16 UTC time. It covers the area between 33 59.94965 N, 124 11.92520 W and 33 59.47952 N, 123 56.80618 W. This places it between OBS16 and OBS17, and a little north of the Murray Fracture Zone.

References

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